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ON THE PSYCHOMOTOR MECHANISMS OF TYPEWRITING

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"The record of the accuracy remains long after the speed is forgotten."

Typewriting is one of the most important industrial operations. To many persons it is the direct means of livelihood and other persons are continually undertaking its study with a view to making it such. There is perhaps no psychomotor process so directly open to experiment in which efficiency is of such wide practical value. Scientific inquiries into increasing the efficiency of typewriting on the psychological side may have a two-fold aim,

1st. To discover the symptoms which presage success or failure in acquiring the accomplishment, in order that the probable progress of the learner may be predicted, that he may be encouraged so far as possible in a career which promises good results for him, or dissuaded as soon as possible from wasting time in something in which there is practical evidence that he will not succeed.

2nd. To study the various conditions of efficiency in typewriting as affected by different times of day and different work periods, and different techniques of operation, etc., in order to increase so far as possible the efficiency of the skilled operator.

The present experiments were made to get a further insight into the means of attacking these questions and also as a practical introduction to the broad problem of studying psychomotor adaptations experimentally through the media of choice reactions.

Non-Experimental Observations.—Typewriting is in a special position in that it is possible not only to make measurements of performance in it experimentally, but also to compare these with fairly accurate observations under non-experimental conditions where the operator is unaware that the performance is being measured. Subsequent to the experiments, a few observations of this sort were undertaken in which the operators, both of whom are professionals of

years' practise, of course worked at their accustomed desks, and at their own machines, which are Remingtons. They did not write the same material but it was of the same sort, namely portions of clinical records. Intrinsically, one operator's copy may have been slightly more difficult than the other's, but on the other hand this operator is much more accustomed to this sort of copy than the other. Timing was with the stop watch, by pages, and the finished product was later examined for errors. Results are shown in the following table:

FASTER AND LESS ACCURATE OPERATOR

Observation	Number of Strokes in measurement	Average Strokes per second	Errors	
			Number	Per cent
Day I— <i>a</i>	374 ¹	3.17	5	1.34±
<i>b</i>	1518	4.34	3	0.197
<i>c</i>	1466	4.14	3	0.204
<i>d</i>	1694	4.58	7	0.414
<i>e</i>	1613	4.48	9	0.559
Day II— <i>f</i>	1647	4.64	4	0.243
<i>g</i>	1466	3.44	10	0.681
<i>h</i>	1583	3.91	4	0.253
<i>i</i>	1611	4.74	9	0.559
Average experimental performance..	1581	5.27	11.9	0.753

SLOWER AND MORE ACCURATE OPERATOR

Day I— <i>a</i>	3507	3.88	5	0.142
<i>b</i>	3620	3.81	3	0.083
<i>c</i>	3545	3.21	4	0.113
Day II— <i>d</i>	3206	4.24	5	0.156
<i>e</i>	3338	3.62	2	0.060
<i>f</i>	856	3.86	1	0.117
Average experimental performance..	1413	4.71 ²	8.5	0.601

¹At this point the operator removed the sheet and began the page afresh

²This operator shows some practise gain in the experiments, cf below.

In each operator, the non-experimental rate appears in general as nine-tenths of the experimental rate; but it is really somewhat closer to it than this because the non-experimental observations include stops for erasures and other pauses that are not wholly relevant to the measurement. The time for external interruptions, when they chanced to occur, was taken out. The experimental conditions cannot, according to the above, be said to have produced, as such, individual differences in speed foreign to the differences of ordinary performance. The case is quite otherwise with the errors, for while in the former operator the errors in the non-experimental observations are 55% of those under experimental conditions, in the latter operator they are but 18.6%, the latter operator making, in general, over five times as many errors with the experimental conditions as without them, the former

one only about twice as many. There was a noteworthy difference in the co-operativeness of the two operators in the experiments, to which this may be related.

The Experiments.—The machine used was a Remington Standard Typewriter No. 10. Contacts with platinum facings were so adjusted to the machine that one electric circuit was made whenever a key or the spacebar was struck, and another only when the spacebar was struck. These circuits operated signal magnets whose movements were recorded by ordinary graphic methods. The speed of the recording surface was approximately 12 mm. per second, the time intervals being marked by a Jaquet Chronograph.

The table and chair employed experimentally had been used for years in typewriting by both operators, though it was not being so used by them at the time of the experiments.

The experimental work by each operator consisted in writing for five minutes at the beginning of work, about 8.30 each morning, and for five minutes again at the conclusion of the morning's work period, about 12.00 m., for fifteen days. Both operators of course wrote the same copy on corresponding days. The copy was taken from Emerson's Essays, as a text free from dialogue or italics. This material is foreign to what the operators are regularly accustomed to (clinical records and business letters), being more involved and obscure, with a different vocabulary.

The external marginal stop was set so that the bell rang at 61, and the stop became effective at 69 on the scale.

The operators were not given verbal instructions, but typewritten ones, which were as follows for the first ten days:

At the word "Go," copy the given text, beginning at the point marked with pencil, and continuing until the word is given to stop, as it will be after five minutes of writing. The lines of your writing will be single spaced. Write at your best working speed, that is, the speed by which you would wish your efficiency as an operator to be judged. Make no stops for corrections, make no strikeouts, and do not use the back-spacer.

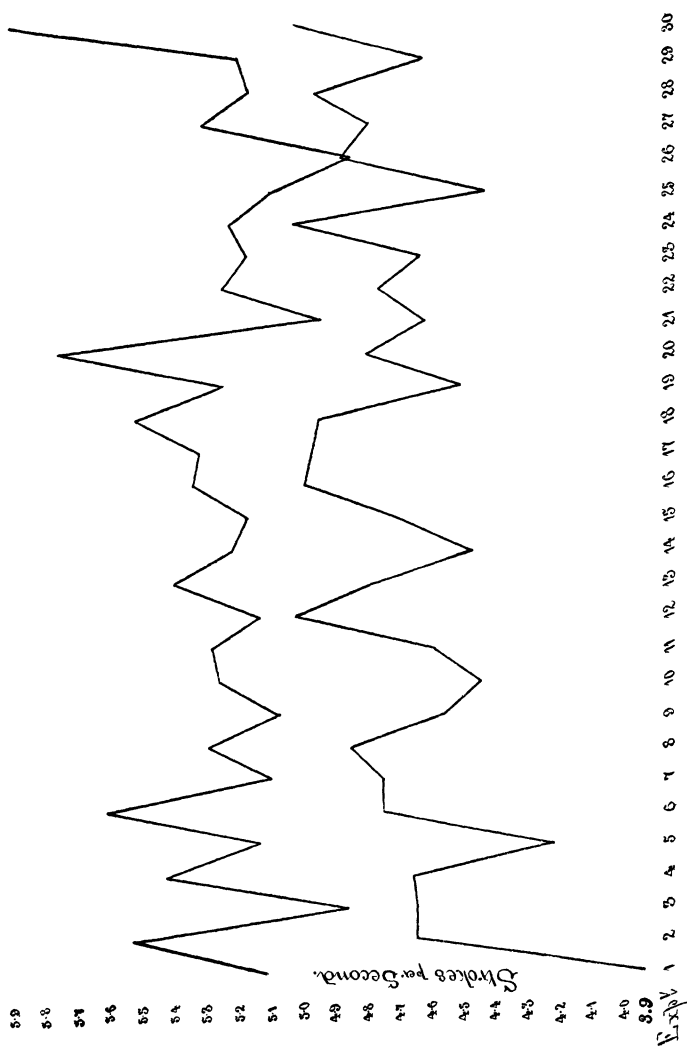
For the last five days the instructions were as follows:

At the word "Go," copy the given text, beginning at the point marked with pencil, and continuing until the word is given to stop, as it will be after five minutes of writing. The lines of your writing will be single spaced. Aim to make no errors, and write at the best speed that will make this possible. Make no stops for corrections, but the back-spacer and strikeouts may be made use of at will.

The instructions should have been given in the reverse order from that here quoted; from this standpoint the procedure is not very sound.

The reaction of both operators to these instructions was to write at abnormally high rate for them, with a correspondingly large number of errors.

Elapsed Time of the Total Process.—This concerns the amount actually written in the 5 minutes—the ordinary practical measure of typewriting speed. It is usually stated in



terms of "words per minute," but this means very different things according to the class of copy used, quite aside from its familiarity. More precision may be sought by measuring not the number of words but the number of *strokes*, that is, touches which result in a forward movement of the carriage. The space-bar is here counted as a stroke, though it is much quicker than the strokes of the keys. On the other hand, shifted keys also count as one stroke. This number of strokes is the absolute measure of the amount of typewriting done in the period; it is considerably affected by at least one other factor, the time of returning the carriage after each line. The question of accuracy is separately dealt with. The following curves give the average number of strokes per second, for each five minute period of writing in the thirty days' experiments, with the two operators.

Time of Separate Processes; the Carriage Return.—This is the longest single process involved in typewriting. With the present machine, it requires merely a backward sweep of the hand, against the proper lever. The average time per line consumed in this process was distributed as follows for the two operators:

Seconds....	.4	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	Over
Records:																		
1-15....	1	..	27	61	69	32	28	12	15	15	4	11	1	1	6	1	1	7
15-30....	1	2	51	70	85	37	22	21	15	9	4	4	1	..	4	4	2	8
Records:																		
1-15....	1	..	..	..	1	14	42	52	55	49	29	21	9	15	2	3	..	11
15-30....	..	..	..	..	1	7	31	49	95	50	42	14	14	5	8	5	..	1

The general median time of the carriage return in the first quoted operator is .87, in the second quoted, 1.28 seconds.

Book's allowance of three strokes for the carriage return would therefore be too little for these operators. The carriage return takes the time for about five and a half correct strokes in the first operator and for about seven and one-third correct strokes in the second.

The methods habitually used by the two operators are not the same. One operator brought the thumb against the hook in the lever, and pushes it back with a single extensor movement of the arm; the other grasped the lever with the fingers, giving it a distinct twist. These latter motions result in a decrease of some 3% in total typewriting speed, not to mention the additional muscular strain put upon the arm.

Carriage Return in Paragraphed Lines.—Although the first lever of the column selector was set at 10, and the start of

every portion of copy was paragraphed to begin at this point, neither of the operators used the column selector for paragraphing, but returned the carriage by hand for the paragraphs also, making corrective movements (or not) with the space bar and back-spacer. One operator aimed to begin paragraphs at 10, but began them elsewhere, usually at 11, in 8 cases out of the total 36; the other aimed to begin paragraphs at 5, but began them elsewhere, regularly at 6, in 9 cases out of the total 30. When the next line begins a paragraph the time of the carriage return is distributed as follows in the two operators.

Seconds.....	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	Over 2.0	Median
Operators...{	1	3	1	5	3	7	3	3	3	2	1	2	4	1.43
	..	3	2	4	5	1	1	3	3	2	1	1	4	1.45

Carriage Return as Affected by the Marginal Release.—One of the operators made no use of the marginal release throughout the experiments. At the end of experiment XIII the other observed that it was set before the end of the line and during the succeeding experiments operated it in all 19 times. Apparently the fact of having been preceded by an operation of the marginal release makes the carriage return slower than it would otherwise have been by over 33%, as shown in the following distribution:

Seconds	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	Over 2.0	Median
Operator...	1	1	3	2	3	4	1	1	..	..	..	1	..	..	2	1.17

Time of Operating the Marginal Release.—The time of operating the marginal release in the 19 cases mentioned above is between 1 second and 2.5 seconds, averaging 1.6 with an m. v. of .36 seconds.

It is thus apparent how the use of the marginal release cuts into the typewriting speed, not only by the time taken to operate it but by reducing the speed of the carriage return, so that the learner should be firmly trained to resort to the marginal release as little as possible.

The Back-spacer; Inhibition and Time for Operating.—Under the conditions it was not practicable for the operators to overcome the long-standing habit of using the back-spacer. One operator used the back-spacer 6 times during the days it was not supposed to be used, the other 69 times. The inhibition gradually improved, the uses of the back-spacer being distributed as follows through the successive experiments.

Experiment.....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No ^o of backspaces.	10	6	3	8	4	1	6	1	5	2	1	2	4	4	4	2	1	2	2	1

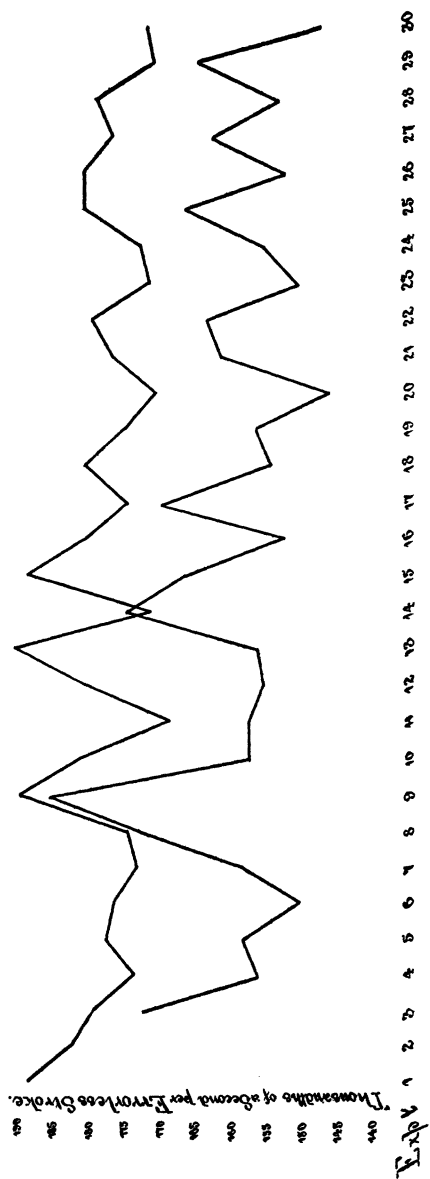
For the last 10 days the use of the back-spacer was part of the conditions of the experiment. The strikeovers were measured, giving the time lost through the necessity of operating the back-spacer. This is considerable, averaging about a second in each operator; a back-spaced strikeover thus takes as much time as five or six correct strokes.

Average Time of Strokes in Errorless Typewriting.—This comes as closely as possible to the actual speed of the typewriting process uncomplicated with extraneous factors such as the carriage return, the back-spacer, etc. As a more or less arbitrary determinant is taken the time required for three errorless lines in each record that contain the least evidences of blocking. The time for writing the lines is divided by the number of strokes in them giving the average time for each stroke. No statement of variability can be given for individual strokes. The results for the successive 30 experiments are as follows in the two operators: (See cut, p. 54.)

These figures must not be thought of as true reaction times. These it is impossible to obtain because the instant of stimulation cannot be fixed. They are shorter than most elementary choice reaction processes, indicating a large amount of overlapping, of which indeed one seems to be introspectively aware.

Steadiness of Typewriting Rate.—The method employed does not lend itself to precise measurement of the variations between the individual strokes. If the experiments were being repeated more attention would be paid to this. Instructions to learners lay some stress on the value of sacrificing speed to steadiness, and psychology has seen in the mean variation a criterion of attentional control. The difficulty in the way is that the rate in writing any material is very dependent on the familiarity of it to the subject and of course the same material is not equally familiar to different subjects any more than it is in shorthand. At the beginning of typewriting practise this difficulty would not be so serious, and a good measure of steadiness of writing rate will be an important factor in predicting the future efficiency of learners.

Book calls attention to the presence of various important processes in typewriting, of a more strictly mental nature, which do not show in the learning curves. If this means that an accurate control of introspection is necessary for the prediction of future efficiency in the learner the practical value



of typewriting measurements will indeed be seriously limited in this direction. But it is doubtful if the actual conditions of learning have yet been closely enough studied, with the following up of the future efficiency of such learners, to warrant pessimistic conclusions.

Relation of Speed to Accuracy.—Of course we know that in general practise improves both speed and accuracy in typewriting; the novice writes slower and makes more mistakes than the expert. Between individuals a broad positive correlation thus obtains between speed and accuracy that need not be confirmed experimentally. On the other hand, if an individual speeds above his optimal rate, more errors are produced, and the same is the case if he tries to write slower. In these experiments the slower writer also makes the fewer errors. A more legitimate question is whether, on days when a highly practised subject writes faster, he also tends to write more accurately or not. In calculating this for the present operators the first ten records were excluded on account of their showing, at least in one operator, too much indication of practise.

The measure of accuracy is here the number of *errors* made in the five minute period. The measure of speed is the average time per stroke for the five minute period.

For the last 20 days the Pearson coefficient of correlation between the given measures of speed and accuracy were .44 for one operator, and .54 for the other. This is in line with the general findings in other psychological functions; increased speed and accuracy go hand in hand, "more haste less speed." It is not conclusive however, since the material necessarily varies in difficulty from day to day and an easy passage is of course written more accurately and faster than a difficult one. Then too, errors tend to retard the rate through the blocking which the consciousness of them produces. The best approach to the matter is by comparison of the rate of false strokes with that for correct ones, and this we are not in a position to do here. Very trustworthy data of a similar nature have however been obtained by Henmon, who has kindly put the material¹ at my disposal for the purposes of this study.

In central tendency, false reactions are regularly shorter than correct ones, but the differences are not so great as to raise the question of essential prematurity in their production, save for Subject S. in the experiments on lines. Often they

¹ Henmon: On the Time of Perception as a Measure of Differences in Sensations. *Archives of Philosophy, Psychology and Scientific Methods*, No. 8, 1906.

are very much longer and they are, as would be expected, quite variable. Since nearly every false reaction has an even chance of being superficially "correct" there are doubtless many more of them than come to light statistically. A subject may direct from his own introspection that a certain reaction be discarded even though the correct movement has been made. Though it is not by any means so regular as with the correct reactions, the false reactions show the same general tendency to become longer as the difference between the stimuli to be discriminated becomes less.

Number of Errors and False Strokes.—The process of type-writing from copy involves a great number of fairly complicated psychomotor adjustments following upon each other in rapid succession. These adjustments do not always run smoothly, but on various occasions incorrect and false adjustments occur. These false adjustments result in "errors;" their effects are seen in false strokes upon the machine making imperfections of the transcript. Two points of view are possible in considering the mistakes. From the immediate objective standpoint it is the "false strokes" alone that count, the more false strokes the worse the copy, but from a psychological standpoint it is plain that circumstances may arise in which a single faulty mental reaction may result in an indefinite number of false strokes. When *admiration* is read and written *ambition* the number of false strokes is a number equal to the letters in the word wrongly written, and yet there is only one real psychomotor "error." Most errors involving more than two false strokes are of this kind, that is, due to misreading the copy. Thus,

1. A *false stroke* is any stroke followed by a forward movement of the carriage which requires correction in order to produce a perfect copy.

2. An *error* is a faulty psychomotor adjustment resulting in the occurrence of one or more false strokes.

The actual number of errors in the records together with the false strokes they involve is as follows in these experiments:

OPERATOR							OPERATOR						
Exp.	No. of errors	No. of false strokes they involve				Total false strokes	No. of errors	No. of false strokes they involve				Total false strokes	
		1	2	3	Over 3			1	2	3	Over 3		
1	20	17	2	..	(38)	59	20	17	2	1	..	24	
2	13	12	1	..	..	14	15	13	2	..	..	17
3	5	4	1	..	..	6	12	12	..	..	..	12
4	11	11	..	..	..	11	10	9	1	..	..	11
5	12	9	1	1	(7)	21	8	7	1	..	..	9
6	12	8	2	1	(47)	62	14	12	1	1	..	17	
7	19	16	2	1	..	23	13	11	1	..	(10)	23	
8	9	8	1	..	..	10	6	6	..	..	..	6
9	10	5	2	3	..	18	17	15	2	..	..	19
10	4	4	..	..	..	4	10	10	..	..	..	10
11	5	3	1	..	(36)	41	11	8	1	1	(39)	52	
12	3	2	1	..	..	4	21	19	1	1	..	24
13	8	7	1	..	..	9	12	11	1	..	..	13
14	15	13	..	2	..	19	14	13	1	..	..	15
15	5	5	..	..	..	5	14	13	1	..	..	15
16	5	5	..	..	..	5	13	10	3	..	..	16
17	4	2	1	1	..	7	13	12	1	..	..	14
18	8	7	1	..	..	9	11	6	4	..	(10)	24
19	12	8	1	..	(8), (43)	61	19	17	1	1	..	22	
20	8	7	1	..	..	9	7	7	..	..	..	7
21	11	11	..	..	..	11	9	7	2	..	..	11
22	6	6	..	..	..	6	12	10	..	1	(43)	56
23	6	6	..	..	..	6	11	9	2	..	..	13
24	7	7	..	..	..	7	10	9	..	1	..	12
25	7	6	..	..	(78)	84	13	10	2	1	..	17
26	7	5	1	..	(8)	15	13	12	..	1	..	15	
27	7	7	..	..	..	7	9	5	3	1	..	14
28	5	5	..	..	..	5	10	10	..	..	..	10
29	8	8	..	..	..	8	6	5	..	1	..	7
30	4	4	..	..	..	4	3	2	..	1	..	4
Av.	8.5	Total				550	11.8					509	
M. V.	3.5						3.0						

By far the greatest number of errors involves only one false stroke; that is, they represent simply the striking of one wrong key, after which the writing proceeds correctly. Those involving two false strokes are nearly all transpositions. Errors of more than two false strokes, including many with excessive numbers of false strokes, are practically all misperceptions of the copy.

Kinds of Errors, Different Psychic Levels that they Represent.—An error is the product of interference with the normal adjustive processes from somewhere. The error of writing

admiration for *ambition* is obviously a very different sort of error from that of writing *amvition* for *ambition* and one much more serious in its effects upon the copy, just as the despatch of false orders on the battlefield is more costly than the blunder of an individual soldier. Originating as they do quite outside of and not involving any defect in motor adjustments they may be thought of as errors of the highest level type.

Superficially there is a distinct line of cleavage between the uncommon, but far reaching errors of this sort, and the ordinary mistakes which are simply substitution, transposition or addition of a stroke or two. Three questions present themselves in regard to these very transitory breakups in the adjustments. First their relation to consciousness, second their relation to the time of the immediate and surrounding processes and third their relation to the content of the copy surrounding them.

On the first little is to be said here, indeed the conditions inherent in the normal typewriting process are prohibitive of immediate introspection. It is doubtful if much more can be done with this feature than Book has already done. There may or may not be consciousness of having made an error. The faulty ideomotor processes that are expressed in the error may or may not be present in consciousness before the error occurs. More regularly however it is the actual making of the false stroke that brings the process into consciousness, at least so far as insight into its falsity is concerned. Sometimes the idea of falsity (whether conscious or not we have no means of knowing) seems to come before the stroke is completed so that the key while wrongly struck leaves an impression lighter than the normal. As under the conditions of typewriting the memory of all conscious process must very quickly fade, one can seldom be even half sure of how much in any given process has been conscious.

One reaches firmer ground in the time relation of the errors. Where an error involves a block in the typewriting process at all, which it does not necessarily do, its most frequent position, in the data examined, is directly after the false stroke. Sometimes it does not come for another stroke and again it may come a stroke before. Occasionally too, there is a slowing of the writing process for some strokes before the error, indicating a gradual failure of the adjustments, though we do not know its relation to consciousness. The length of these blocks is seldom over $1\frac{1}{2}$ seconds. Through the unfortunate mistake of trying to eliminate the

use of the back-spacer the interpretation of these blocks is not clear. The writer believes that they represent essentially the inhibition of the tendency to use the back-spacer the instant there is awareness of a false stroke, and that the back-spacer is struck nearly, if not quite, as promptly after the false stroke as the next key would be after a correct one. The indication is certainly that false strokes sometimes occur with insight into them and sometimes not.

What lies back of the failures of attentional control that show themselves in the errors is unfortunately beyond the scope of this study. What stroke is falsely made may be governed by quite deep-lying sources, and from the immediate surroundings of the copy, and from certain motor habits formed in typewriting common words, as will be illustrated.

It should be noted that the false strokes are generally effective strokes at wrong keys; inaccurate fumbling strokes at right keys play an insignificant part. During the entire gathering of the material no instance is recalled of two keys struck simultaneously so as to lock them.

The errors fall naturally into four sorts,—omissions, substitutions, transpositions (metatheses) and additions.

Their material will be presented in this order. It is most probable however that similar psychic mechanisms may result in any of these errors, what kind of error results depending mostly on the precise point of time at which normal control over the whole process is restored.

In quoting examples of the errors, it is not practicable to reproduce their smoked paper records, but it is usually desirable to indicate some features of them diagrammatically, i. e., slowness in writing rate, the place of occurrence of a block and its length. The scheme is adopted of leading the letters in the word where the writing is obviously slow, and indicating blocks by a row of periods inserted where the blocks come on the record, and indicating at this point the length of the block, thus,

Error	Correct Form
f a m i k i a r i t y	f a m i l i a r i t y

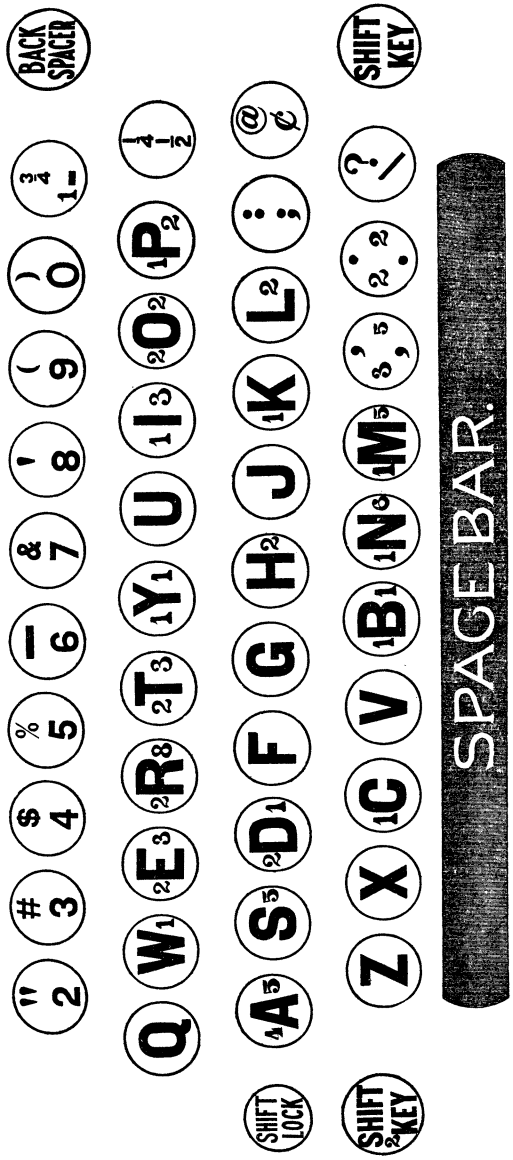
would mean that after a period of slow writing of the word up to this point, *k* was erroneously written for *l* and that immediately afterwards a block of about 1.4 seconds ensued after which the writing was again taken up normally. This scheme, supplemented by remarks, is used in representing nearly all the errors quoted.

Omissions.—An error of omission in the transcript results whenever the psychomotor process for striking the given key is not sufficiently effective to produce the legible impression of that key. A key may be struck too lightly to make a legible impression and yet strongly enough to trip the carriage. It is possible and even probable that many of these cases are abortive false strokes but there is no means of knowing this. In one of the operators there were 36 cases in which the carriage moved forward without a legible impression of the key struck. In the other the number cannot be arrived at, but the number of back-spaces observed is often greater than the number of strikeovers, which excess probably represents the correction of omissions of this kind. The cases in which the carriage did not move forward are illustrated as follows, the numerals lettered on the chart indicating the number of times each stroke of the given key was omitted by each operator.

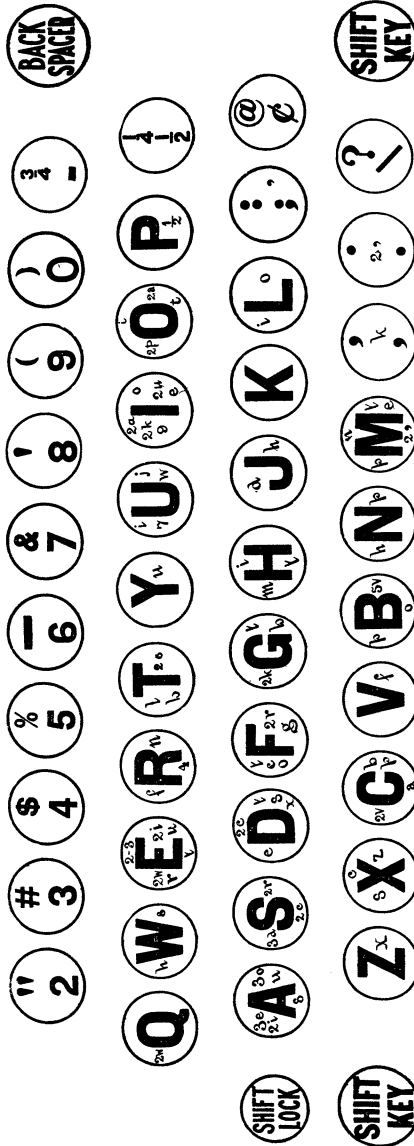
Certain keys seem to be subject to omission out of proportion to the number of times their strokes occur, but it is not possible to make further interpretation of this; *m* and *n* seem relatively difficult to reach. Operator J shows many more of these omissions than operator T does and they are chiefly distributed among the keys *a*, *s*, *r*, *m*, and *n*. The letter *a* is that most frequently omitted by operator T. The letter *e*, by far the most frequent of all, is not especially subject to this or any other sort of error.

Substitutions, Transpositions, etc.—The substitutions are illustrated in the accompanying chart. Here again the number of errors on a given key may be out of proportion to the frequency with which its stroke occurs. The two operators also differ in this respect. Operator T has many errors on *m* and *n*. Operator J shows distinctly more errors on *m*, though *n* is the more frequent letter. The kinds of errors also differ. Operator T shows evident cases of tending to substitute one particular stroke for another, as *j* for *h*, *z* for *x* and the comma for *m*. The errors of Operator J are more scattered except that *v* is often struck for *b*. In the errors made on *a* operator T substituted mostly neighboring letters. Operator J writes other vowels without regard to their proximity.

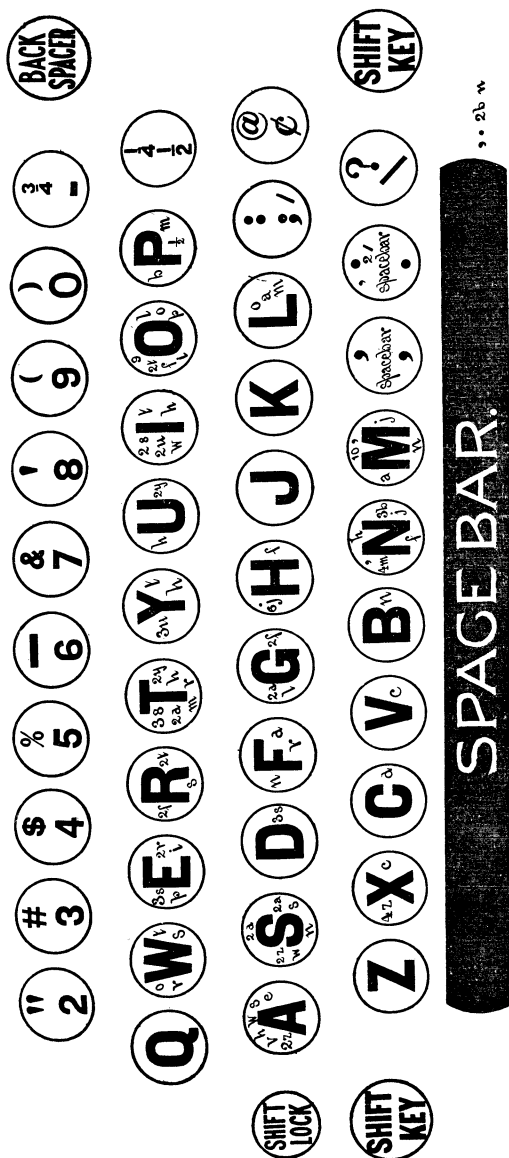
When neighboring letters are struck one is unable to know what is psychologically a very important thing, namely if the finger simply "dropped" off the key or if a wrong finger was used. It is certain that errors of both kinds occur.



Omissions by the two operators. A figure on the left of the letter indicates the number of times that letter was omitted by operator T, on the right, by operator J. Thus *e* was omitted twice by operator T, three times by operator J.



Substitutions by operator J. The large letters indicate the key which should have been struck; the small letters indicate the key which was erroneously struck. Thus *g* was twice written *k*, once *t*, and once *b*.



Substitutions by operator T. The large letters indicate the key which should have been struck; the small letters indicate the key which was erroneously struck. Thus *e* was three times written *s*, twice *r*, once *p*, and once *i*.

False strokes may result from the finger striking on a wrong bank of keys or being out of lateral adjustment, or the stroke may be in the corresponding position of the other hand, as the interchange of *e* and *i*; this is rare in the present material though a recognized type of error non-experimentally. The false stroke may also occur through a different finger with a different hand, as *n* for *r*, *w* for *u*, *e* for *m*.

There are doubtless errors which are determined essentially by the hands momentarily getting out of position through fatigue or some distraction. This however could produce only false strokes on neighboring keys and the fact that the false strokes are not in general "inaccurate" in a motor sense speaks further against this determinant as being of general importance. When a distant key is struck, as above, and with another hand, there must be a positive determinant for this particular key and it seems that the same factors at work here operate also, and more strongly, in the case of neighboring keys. It seems therefore that we should not speak of two types of errors, i. e., on neighboring and distant keys, but rather of two factors in the production of errors, one of which effects a mere dropping of the hands out of alignment and the other directs them positively towards a definite false stroke. These are not mutually exclusive but reinforce each other. Thus, a frequent type of error is the anticipation of a stroke really occurring later in the word and this seems to occur more easily if the anticipated stroke is in proximity to the stroke it replaces. Two typical cases are,

Error	Correct Form
^{1.0 s} mu mor	humor
^{.9 s} t r u u m p h s ²	triumphs

The mental process of anticipation is then more likely to express itself in a false stroke—that is, the factors of proximity and "distraction" reinforce each other in determining the false stroke.

In connection with these anticipations, or as they are called by students of linguistics, "regressive assimilations," and the transpositions or "metatheses," as they are technically known, a quite interesting finding appears. To quote from some analogous studies of the errors of speech and writing movements:

² In this error a motor habit "tru" may also be effective. "*Überdeterminierung*" looms large in the mechanism of these errors.

"It will³ be noted that very generally in the regressive lapses of Meringer and Mayer, and almost invariably in both the phonetic and graphic material of Bawden, the error is discovered, or, at least, so indicated, before the proper place of the erroneously made movement is reached. This is also universally the case with the writer's graphic material; the error is discovered before the proper place of the assimilated letter is reached by the pen. This fact opens to serious question the nature of the regressive assimilation. . . . Suppose the subject is to write *Engadin*. He writes *End*; now if he were to go on normally and write *Endadin*, there might exist a true regressive assimilation. But of this there are almost no instances. In practically all cases in which the error is not discovered before the proper place of the assimilated movement is reached the word appears as *Endagin*, a metathesis. It is probable therefore that most if not all regressive assimilations are really abortive metatheses, in which the error was discovered, or the primary memory of it lost, before the arrival of the second member. Something of the sort is indicated in those lapses quoted by Meringer and Mayer in which the speaker's introspection gives evidence that the apparent regressive assimilation would have been a metathesis if the error had not entered consciousness. Thus, "*Ich werde auf das Ei . . . auf das Kreuz vereidigt*" (p. 35). Unkorrigiert hätte der Fehler so ausfallen können; "*Ich werde auf das Ei verkreudigt*." And again, "*Griebes . . . Liebesgram*" (p. 37); *Ich glaube, ich wollte sagen Griebeslam.*" This is one of the very rare instances in which the affected portions are not of the same extensity.

"The second member should therefore be considered as having, as such, no part or lot in the lapse. It will be noted that in most instances of the graphic metathesis, the affected elements are closer together than in the regressive assimilations, the relative separation of the movements in the latter being probably related to the greater time given for discovery of the error and change in the focus of consciousness. It will be noted that this latter condition is all that is needed to abort the metathesis, and that this may take place without consciousness of the error. The corollary of the non-existence of the regressive assimilation, save superficially, would seem to be obvious. If a certain movement is erroneously anticipated, that movement is not made again so long as the primary memory of it persists; a fresh start must be had, so to speak, the focus of consciousness must change, before the movement may be again attended to.

"There is, in fact, no case of motor metathesis which is not, in this sense, a progressive dissimilation, the second member being erroneously placed because of a consciousness of the individual movement-complexes, their number and identity, stronger than the consciousness of their order. When having made a linguistic movement prematurely we arrive at that space in consciousness which it should naturally fill, there is involuntarily substituted the movement that it displaced."

An examination of the present material confirms the above by affording an objective record of the temporal block between the two processes. If a stroke is written anticipatorily, that stroke is not made at the point from which it was anticipated

³ Wells, *Linguistic Lapses*, *Archives of Phil., Psych. and Sci. Methods*, No. 6, 1906, pp. 86, ff.

without a definite block in the writing process somewhere preceding it. The cases which bear on this point are (in addition to *mumor* and *truumphs* above),

Error	Correct Form
(sp) ^{.8 s} ..leas ^{1.2 s} .....s	leads
^{.3} i..t ^{.8 s} .....f it	if it
^{.4 s} m....i ^{1.0 s} c r o s p...o p i c	microscopic
^{1.4 s} g i.....i t t e r i n g	glittering
^{2.0 s} t i e.....e	time
^{.6 s} e c u.....c a t i o n	education
^{1.2 s} i n t i.....i t i o n s	intuitions
^{1.4 s} o.....f.....o m ^{.4 s}	from
^{.5 s} c o.....m e s t i c a t i o n	domestication
^{1.5 s} o r n a t.....e n t	ornament
^{1.2 s} i d t.....e n t i.....t y ^{.4 s}	identity
^{1 s} w.....a w a k e n i n g	awakening
^{.4 s} g r e a t h.....(s p).....d e p t h ^{.6 s}	great depth
^{.7 s} i n d i v i d.....u a l	individual
^{1.0 s} a n t u.....q u i t y	antiquity
^{.4 s} a h.....o t h e r	another
^{.8 s} (s p).....g u n.....g u s	fungus

Exceptional cases are:

Error	Correct Form
Jusus	Jesus
essentiam man	essential man
Imagintation	Imagination
they e y e s	the eyes

If no block is shown on the smoked paper record then the regular result is a transposition. Accordingly most transpositions run off without blocks before or within the transposition, the cases on this point being as follows:

Error	Correct Form
e x i s t, s	exists,
t u r e	true
p a r i s e	praise
h a p p n e	happen
r a o d	road

The bias	Thebais
Brahim	Brahmin
(sp) try.... ^{2.0 s} (tyrannized, cf. below, p. 69)	tyrannized
(sp) kindg.... ^{1.2 s} om	kingdom
sia.... ^{.6 s} d	said
infel.... ^{.3 s} x-	inflex- (ibility)
real.... ^{.8 s} tion	relation

But a block may occur between the transposed letters, and yet a wrong letter be written in transposition as shown in the following:

Error	Correct Form
hod.... ^{1.0 s} l	hold
alr.... ^{1.2 s} am.... (sp)	alarm
las.... ^{1.4 s} w	laws
pr.... ^{1.6 s} eform	perform
is.... ^{.8 s} t	its

Transpositions occur between strokes of different fingers of different hands, of different fingers of the same hand and even of the same finger of the same hand. They are usually between adjacent strokes (*prosperiteis*), but not necessarily so, (*proterpy*). Nearly always they represent the interchange of two individual strokes. The writer has observed, not experimentally, but one instance (*unpredijuced*) where the patterns of two strokes are interchanged.

In speech and writing there are instances where a sound or letter is taken out of its correct place and put somewhere

else, *amen* for *mean* and *sanct*.....^{.6 s}*urya*.....^{1.2 s} (.) for *sanctuary*. The only other apparent instance of this in the present material occurs in the only word that itself shows a peculiar tendency to be written wrongly, *virtue*, the mistakes made in writing this being as follows:

Error	Correct Form
virtu.... ^{.6 s} r.... ^{.6 s} (sp)	virtue
viture	"
(sp) virtur	"
vitu.... ^{2.5 s} e	"
vitures	virtues

The essential thing about these errors is the tendency to write *ture* which, as a common suffix, is probably a motor habit phenomenon. But observe that the misplacing of the *r* tends to eliminate it where it rightly belongs.

The mechanism of this whole process would seem to be the motor phase of the "inhibition of similars" investigated and discussed principally by Ranschburg, on the sensory side. It is doubtful if it has produced actual "dissimilation" elsewhere in the present material, for the following instances, though showing it superficially, may be mere omissions with which the recurrence of the same stroke in the word had nothing to do.

Error	Correct Form
re m i n e d	reminded
no e	none
creatues	creatures
Jesur	Jesus
no to c e	notice } (substitutions)

There is one case however that seems scarcely explicable on this ground,

Error	Correct Form
consit. ^{1.0 S} tu ^{.5 S} ional ^{1.0 S} ly	constitutionally

It is tantalizing to have to quote such a case without its introspective data, and the interpretation is ventured that the second *t* is put in because *t* was omitted where it should first have come and that the cause for the omission of the last *t* is intimately dependent on the superfluous one inserted two strokes before. The subject writing above expresses a sense of motor pattern for words in typewriting, thus, "I spell the word mentally, but the fingers travel faster than I can spell it. Sometimes I get through before the mind is through and come out one letter short." This gives a probable clue to the nature of some transpositions, the omitted letter most naturally stepping in to complete the number of strokes felt to be the proper one for the word. This seems most likely in such cases, as given above, where the last two letters are transposed.

Allusion has been made to cases where the error is not concerned with the substitution or transposition of the ideomotor processes for the strokes as such, but with some particular function of them, as where the doubling is transposed in *voicelles*. The present material shows cases of this in *tyrranized* and *morrally*, thus:

Error	Correct Form
(sp) o r r ^{1.0 s} a l l y	morally
(sp) ^{2.0 s} t y ^{.3 s} r ^{.3 s} a n i z e d	tyrannized
thses	these
(sp) T u ^{.8 s} n k e r	Thinker

That the former at least is not an error of spelling is indicated by the circumstance that immediately before this error the word has been begun with the three strokes *try*, after which the operator went back and started the word over again. A more complex form of the same mechanism is seen in *theses* for *these*. This error involved no blocks, in fact it and the surrounding material were written at unusually high speed. Fusion appears involved in the case of *Tunker* for *Thinker*, the *u*-key occupying a position between *h* and *i* on the key board.

Mention has been made of errors apparently resulting from the motor habits of writing words more frequent to the operators. Instances of this are as follows:

Error	Correct Form
startin g	startling
the ^{2.0 s} t	that
s p e c ^{.4 s} . . . t a b ^{1.2 s} l e	spectacle
po w e ^{.6 s} . . . t ^{.3 s} s ^{.4 s}	poet's
powet	poet

Insertions of superfluous strokes (additions), where they are not assimilations from the context appear to be generally produced in this way, e. g., *repulsiong*, *meantimes*, *wisdome*, *either* (for *ether*).

Three cases are worth quoting as illustrations of somewhat severer breakdowns in the adjustments. In writing the word *obedience* the operator first writes slowly *obec*, then back-spaces once and writes *dic*, then back-spaces again and writes *ecn*. Whether this last would have been corrected cannot be told as the writing period ended here and the operator was stopped. Characteristic is the irrepressible breaking through of the *c* before its time. The whole process goes on more slowly than the usual rate of writing.

For *the*, the strokes *fht* were written. They were not blocked, but somewhat slowed and the next word shows considerable delay between the strokes.

For *own* the strokes *ouw* were written as follows:

Error	Correct Form
$\begin{array}{c} .5\text{ s} \quad .4\text{ s} \quad 2.0\text{ s} \\ \text{ou} \dots \text{w} \dots (\text{sp}) \dots \text{heaven} \end{array}$	own heaven

Probably the *u* is a motor habit error (*our*) and the *w* is a belated correction, the *n* being kept out by the "pattern" sense of the number of strokes in the word. Immediately after *w* there was a block of .4 seconds before the space bar was struck and then a block of two seconds before the next word "*heaven*" was begun. There was no back-spacing although in this experiment the directions were not against it.

There was no noteworthy individual difference in the kind of errors made except that there are four times as many transpositions in operator J as in operator T. Only the study of further subjects could show if this fact was in some way inherent in different methods of writing used by each. With both operators substitutions are by far the most common, omissions next, additions next and transpositions rarest.

Practical conclusions may be stated as follows:

The experimental conditions caused in both operators a more rapid and less accurate writing than normal for them.

Under the non-experimental conditions both operators wrote at about 9/10 of the speed shown under experimental conditions; one operator made about half as many errors under non-experimental conditions; the other about 1/5 as many.

In the experiments both speed and accuracy average better at the noon period than at the morning one.

An unusual amount of work during the morning makes the noon efficiency lower in both speed and accuracy; it has a more deleterious effect on the accuracy than on the speed. The general gain in efficiency from morning to noon does not appear to be dependent on the doing of typewriting in the meantime.

It is reasonable to expect from these results that typewriting will be in all respects better done towards noon than at the beginning of the working day.